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SILVICULTURAL SYSTEMS FOR  
BIOMASS PRODUCTION ON SANDHILLS<sup>1/</sup>

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Abstract.--The suitability of three low-intensity silvicultural systems, i.e., natural oak stands, natural Choctawhatchee sand pine (*Pinus clausa* var. *immuginata* D. B. Ward) stands, and Choctawhatchee sand pine plantations, for biomass production on southeast sandhills was investigated. Productivity was lowest in the natural oak stands, intermediate in natural Choctawhatchee sand pine stands, and highest in Choctawhatchee sand pine plantations. Natural sand pine stands should be maintained in that state. Oak stands should be harvested for biomass and converted to sand pine plantations planted at densities of 1 600 to 2 000 trees per ha, with rotation ages of 20 to 25 years.

INTRODUCTION

Scattered throughout the Southeastern Coastal Plain of the United States are over 3 million ha of acid sands (figure 1). These marine deposits from the Pleistocene epoch are an important physiographic feature of central and northwest Florida. They also occupy significant areas of Georgia, South Carolina, and North Carolina in the transition zone between the Upper Coastal Plains and the Piedmont (Burns and Hebb, 1972).

Sandhills soils are typically acid, infertile, and droughty. Because of sorting action during deposition, many are largely quartz sands, ranging to more than 6 m deep. Organic matter content is low because the climate promotes rapid oxidation. Because of the low levels of organic matter and clay colloids, nutrient and water retention of these soils are low (Burns and Hebb, 1972).

Most of the sandhills were once dominated by relatively open stands of longleaf pine (*P. palustris* Mill.), but only scattered patches and isolated trees remain. Most sites were claimed by a scrub oak-wiregrass type following removal of the longleaf in the early 1900's. This scrub vegetation, principally turkey oak (*Quercus laevis* Walt.), bluejack oak (*Q. incana* Bartr.), sandpost oak (*Q. stellata* var. *margaretta* (Ashe) Sarg.), and wiregrass (*Aristida stricta* Michx.), now dominates most areas (Burns and Hebb, 1972).

In Florida and in Baldwin County, Alabama, the native vegetation on many of the sandhills is sand pine. There are two varieties of sand pine which differ considerably in ecology and habitat. The Ocala variety (*P. clausa* var. *clausa* D. B. Ward) is concentrated in the center of Florida on an area of rolling sandhills

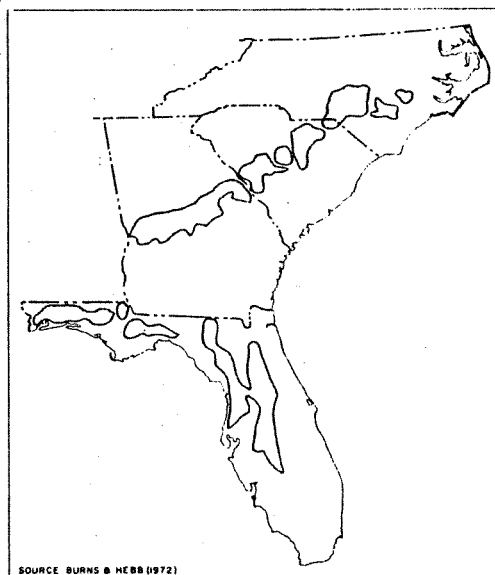


Figure 1. Location of sandhill soils from North Carolina to Florida.

known as the Central Highlands. It has serotinous cones which persist on the tree for many years, storing large quantities of seed. Under natural conditions, fire releases these seeds and dense stands of seedlings become established. Because of planting difficulties and losses to disease, the Ocala variety should not be used outside of its natural range. The Choctawhatchee variety (*P. clausa* var. *immuginata* D. B. Ward) is found along the Gulf Coast of northwest Florida from the Apalachicola River westward into Alabama. It typically has open cones and does not respond favorably to fire. With effective fire control, however, it will seed into, and eventually take over, adjoining scrub oak stands.

Extensive research by the Southeastern Forest Experiment Station, U.S. Forest Service has shown that sand pine is the most productive of 38 species of conifers that have been tested for sandhills reforestation

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(Brendenuehl, 1981). Although rated as moderately intolerant, sand pine is quite tolerant of shade and competition when young. It is one of the few species able to compete with the scrub oaks and grow at reasonable rates on sandhills sites. On the basis of such information, Choctawhatchee sand pine is being used to convert scrub oak areas to pine plantations on sandhills throughout northwest Florida, and to a lesser extent in Georgia and South Carolina.

Although the sandhills may seem unlikely sites for biomass production, they do have some advantages over sites intensively managed for species like sycamore and poplars. Because the sandhills are relatively dry and infertile, there is little competition from alternate land uses such as agriculture and urban development except in central Florida. Therefore, many of the sites are underutilized. All of the silvicultural systems proposed for biomass production on these sites are low intensity systems which require only minimal energy investments. They also have the advantage of operability. Even during very wet periods when operation of mechanized harvesting equipment used in biomass production is not possible on many sites, harvesting can continue without problems and with little site damage on sandhills. Thus, biomass production is a viable use for sandhills. Because of recently completed inventories it is now possible to predict biomass yields and characteristics of the biomass from sandhills. The purpose of this paper is to outline the different silvicultural systems which can be used, and to compare them on the basis of expected yields, and the characteristics of the biomass produced.

#### METHODS

Since the sampling methods have been covered in detail in previous papers (McNab et al. 1985, McNab 1981, Taras 1980), only a general outline will be given here. Selected sample trees were felled, measured, and cut into sections. Each portion of each tree was weighed and subsamples were collected for laboratory determinations. In the lab, samples of the stem and branches were separated into wood and bark.

Specific gravity was determined from immersed green volume and dry weight. Moisture contents were determined by drying to constant weight at 95° C. Prediction equations were developed by linear regression using dbh squared times total height as independent variables after logarithmic transformation. All equations were corrected for logarithmic bias. Tree diameters and heights were measured in randomly established sample plots in representative planted and natural stands of Choctawhatchee sand pine and scrub oak. Productivity figures and biomass characteristics were calculated by applying the developed equations to the tree data from these plots.

#### SCRUB OAK STANDS

The southern scrub oak forest type is typically a mixture of turkey oak, bluejack oak, blackjack oak (*Quercus marilandica* Muenchh.), sandpost oak, and in portions of the range, sand live oak (*Quercus virginiana* var. *geminata* (Small) Sarg.), myrtle oak (*Quercus*

*myrtifolia* Wildl.), and Chapman oak *Quercus chapmanii* Sarg.). Trees in these stands are generally small and of poor quality (McNab, 1981). Because of this, except for some local firewood cutting, this resource is seldom harvested for forest products. However, there is an opportunity to utilize these scrub oaks for fuelwood using a mobile full-tree chip harvest system (Butts and Preston, 1979). This is a case of utilizing an existing resource and thus, there are no energy or dollar inputs required except for the harvest operation. These stands will yield an average of 1.6 mt per ha per year of biomass or about 48 mt per ha at age 30 years (Table 1). Although these yields are low compared to those from other systems, they are well above the yield needed for an economic harvest with a mobile biomass machine (Anon. 1980). In addition, the oak wood is dense (McNab, 1981) and low in moisture content (Table 2) making it well-suited for use as fuelwood. Also, harvesting can be done with the leaves off which will help maintain site productivity because nutrients in leaves will not be removed.

Table 1.--Total above-ground biomass yields from sandhills sites under different management systems.

Location	Age	Density	Dry weight	
			Total	Annual
	(years)	(trees/ha)	(mt/ha)	(mt/ha/yr)
Choctawhatchee Sand Pine Pulpwood Plantations				
Northwest Florida	27	1,560	137	5.08
	27	555	106	3.92
	18	1,980	90	5.00
	18	990	78	4.35
	13	1,385	41	3.16
	12	1,600	31	2.62
	7	4,720	31	4.44
	6	4,110	17	2.87
-----				
Choctawhatchee Sand Pine Fuelwood Plantations <sup>1/</sup>				
Northwest Florida	6.5	7,135	19	2.96
	12.5	6,610	40	3.18
	17.5	12,375	140	7.97-
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Natural Choctawhatchee Sand Pine Stands				
Northwest Florida	40(G) <sup>2/</sup>	1,480	173	4.32
	40(A)	1,480	151	3.79
	40(P)	1,480	129	3.23
	31(G)	1,235	135	4.35
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Scrub Oak Stands				
Georgia	28	1,155	49	1.75
Florida	28	7,165	44	1.57
Florida	36	4,570	52	1.46

<sup>1/</sup> Adapted from Rockwood et al. (1980).

<sup>2/</sup> G is a good site, A is an average site, and P is a poor site.

#### NATURAL STANDS OF CHOCTAWHATCHEE SAND PINE

About 40 000 ha of these stands exist in Northwest Florida and Baldwin, County Alabama, with the largest concentration on and around Eglin Air Force Base. Stands are typically dense, pure, and single-storied, although uneven-aged stands do develop during the initial invasion stage of scrub oak sites (Britt, 1973). Management is relatively easy with little tending, other than fire protection, required between regeneration and harvest. Regeneration can be by

either the seed-tree or shelterwood systems. In both methods of regeneration an initial cut is made to stimulate seed production, followed by a final harvest after adequate regeneration is obtained, normally 5 to 10 years later. The seed-tree method is best suited to stands harvested by full-tree chipping. Volume loss to Ips beetle attacks after the initial cut and damage to regeneration during the final cut are typically less. Expected yields range from 4.32 mt to 3.23 mt per ha per year of biomass on good and poor sites, respectively, with rotations of 30 to 40 years (Table 1). As with natural scrub oak stands, energy and capital investments are required at harvest time only.

Table 2.--Average moisture content and proportion of stems, branches, and foliage on a dry weight basis for sandhills sites under different management systems.

Location	Age	Moisture content	Proportion of biomass in:		
			Stems	Branches	Foliage
<hr/>					
(years)		----- (percent) -----			
Choctawhatchee Sand Pine Pulpwood Plantations					
Northwest Florida	27	125	75.2	17.8	7.0
	27	126	76.6	17.3	6.1
	18	124	73.5	18.4	8.1
	18	125	74.7	18.0	7.3
	13	124	72.0	18.9	9.1
	12	123	70.6	19.4	10.0
<hr/>					
Choctawhatchee Sand Pine Fuelwood Plantations <sup>1/</sup>					
Northwest Florida	6.5	143 <sup>2/</sup>	47.6	25.8	26.6
	12.5	158	64.7	22.2	13.1
	17.5	120	80.7	13.7	5.6
<hr/>					
Natural Choctawhatchee Sand Pine Stands					
Northwest Florida	40	96 <sup>3/</sup>	80.0	17.0	3.0
	31	ND <sup>3/</sup>	79.3	17.8	2.9
<hr/>					
Scrub Oak Stands <sup>4/</sup>					
Georgia	28	64	63.0	37.0	
Florida	28	ND	49.0	51.0	
Florida	36	ND	54.0	46.0	

<sup>1/</sup> Adapted from Rockwood et al. (1980).

<sup>2/</sup> For stem portion of trees only.

<sup>3/</sup> ND means no data were available.

<sup>4/</sup> Foliage is not included because stands were sampled with leaves off.

#### CHOCTAWHATCHEE SAND PINE PLANTATIONS

Most of the potential sand pine sites are currently occupied by scrub oak stands. These can be converted to Choctawhatchee sand pine plantations by site preparation and planting. Extensive testing has shown that double chopping is the most effective means of reducing scrub hardwood competition and encouraging planted pine survival and growth on these sandhills sites (Burns and Hebb, 1972). Chopping conserves the limited nutrient capital by leaving the topsoil in place and incorporating herbaceous and woody vegetation into the soil. Seedlings should be placed deep enough to insure that the lower branches are at the ground line after the soil has settled (Burns, 1973). A density of about 12 000 trees per ha will give maximum biomass production (Table 1). Choctawhatchee sand pine should not be planted on soils that have internal drainage problems at anytime during the year as high mortality from

root rot will likely occur. With proper site selection, site preparation, and planting, survival has been shown to be consistently high on sandhills throughout the Southeast (Burns, 1973). After establishment the only management needed is fire protection and possibly some sanitation cutting to control bark beetle infestations which can occur following stand damage. Although somewhat more intensive than the other systems, energy and dollar inputs are still quite moderate.

#### BIOMASS YIELDS AND CHARACTERISTICS

As shown in Table 1, biomass yields depend on density, rotation age, and the silvicultural system. Scrub oak stands have the lowest productivity while Choctawhatchee sand pine biomass plantations have the highest, and natural and pulpwood type plantations are intermediate (Table 1). It appears that density has little affect on yields from scrub oak stands, but in Choctawhatchee sand pine plantations annual productivity increases as stand density increases. Productivity also increases in plantations with longer rotation ages. For a density of about 1 480 trees per ha, annual biomass production in dry metric tons per hectare should be about 2.9, 4.65, and 5.08 at ages 12, 18, and 27 years, respectively.

Factors which affect the quantity of biomass produced also affect its quality. Biomass from scrub oak stands has the lowest moisture content followed by natural Choctawhatchee sand pine stands (Table 2). Moisture content in biomass from sand pine plantations is about double that of scrub oak biomass. Stem material has the greatest value as fuelwood because of relatively low amounts of bark and water and a high density, while the crown has lower fuel value because it has the opposite characteristics. Density within the range of the sample stands had little effect on the percentage of stem or crown material or moisture content and thus little effect on biomass quality. After Choctawhatchee sand pine stands have reached crown closure, which generally occurs at 10 to 12 years, age had very little affect on biomass quality. Prior to crown closure, biomass from Choctawhatchee sand pine stands has a relatively high moisture content, a low percentage of stem, and a high percentage of crown material.

#### CHOOSING A SYSTEM

Harvesting existing scrub oak stands for fuelwood appears to be a viable use of a presently underutilized resource. Once harvested, these areas should be converted to Choctawhatchee sand pine plantations to increase yields. If biomass production is the owner's main objective, then high density plantings on a rotation of 15 to 20 years would be best. However, for most sandhills landowner's, spacings of 1 600 to 2 200 trees per ha and rotation ages of 20 to 25 years are preferable because it will maintain the option of using the material for either pulpwood or fuelwood. Although yields will be somewhat lower, so will be the cost of establishment. Natural stands of Choctawhatchee sand pine should continue to be managed for natural regeneration. Although biomass yields are not as high as from extremely dense plantations, they are equal to those from conventionally spaced pulpwood plantations, the biomass is better quality because of a lower moisture content, and the establishment cost is lower.

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